Influence of curing profile and fibre architecture on the fatigue resistance of composite materials for wind turbine blades

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The fatigue performance of unidirectional glass fibre reinforced epoxy is found to be highly dependent on the manufacturing conditions, where a low manufacturing temperature, for the investigated wind turbine relevant composite material system, is found to improve the tension/tension fatigue life-time with a factor of 10 if compared with a corresponding laminate manufactured at a high manufacturing temperature. It should be noted that a low manufacturing temperature will increased the required mould time significantly and thereby influence the cost of the manufactured wind turbine blade. In addition, the thick laminates typically used in the root section of the wind turbine blades will experience significant exothermically generated temperature raise during the curing process increasing the local manufacturing temperature.

The tension/tension fatigue life-time[1] has been investigated using 3D x-ray computer tomography. Thereby, it has been found during ex-situ fatigue studies, that the fatigue failure mechanism is highly influenced by transverse cracking in the so-called backing bundles which is present in order to ease the handling during the dry fabric layup during wind turbine blade manufacturing. It is a failure mechanism which is judge to be highly influenced by the magnitude of the residual stresses exhibit in the matrix material and therefore also in the secondary oriented backing bundles.

Using fibre Bragg grated optical fibres[2]; the build-up of the cure-induced strains in the fibre-reinforcement has been investigated during a variety of curing profiles of the used epoxy material system. Thereby, it is possible to observe that even though the overall chemical shrinkage of the epoxy material system is independent on the chosen curing profile, the location of the gel-point and thereby the amount of shrinkage occurring in the solid state is highly influenced.

During the study, it is therefore documented that even though a short mould time may be beneficial lowering the manufacturing cost, it has a drawback on the fatigue life time. In addition, it can be expected that the internal part of the thick laminates used in the root sections of a wind turbine blade has a lower fatigue resistance compared with the composite materials used elsewhere.

[1] Jespersen et. al, *Composites Science and Technology*, 136, 94-103, 2016

[2] Pereira et.al., *Polymer Testing*, 50, 125-134, 2016

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